DIGITAL ROAD MAP FOR ADVANCED ROAD AND TRAFFIC MANAGEMENT

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ABSTRACT

Digital road maps play a key role as the basis for road ITS (Intelligent Transport Systems) and various systems for road management. In order to meet this requirement from both public and private organizations, the Japan Digital Road Map Association (DRM) has been established in 1988 and leading the world in standardizing a digital road map database.

Since that time, DRM has made great effort to expand the content of this reliable, integrated national database, based on standard specifications which are open to the public. We are continuing to make improvement and identifying necessary revisions every year. Today, the database is widely used in public and private sectors such as road management tool by national and regional governments, the Vehicle Information and Communication System (VICS), and car navigation systems. Moving forward to the future second stage of ITS, DRM is working on several projects including development and spread of the new DRM Standard Format 21, which can provide a versatile and expandable database.
In the future, we will continue to make our best efforts to build a digital road map database which can handle next-generation digital road map that is truly useful as a common infrastructure for the public and private sectors.

1. OUTLINE OF THE DIGITAL ROAD MAP

Ordinary maps, including road maps, are printed on paper and are easy for us to use and understand. However, in the case of car navigation and road management systems, computers must recognize roads, intersections and others. Therefore, digital cartographic data, in which locations and other information are expressed in numeric form, is indispensable. It is because of the existence of digital road maps that car navigation systems and the like are able to display road maps on their screens and search for the shortest path to the destination.

DRM creates, updates and provides the standard national digital road map database, namely the

DRM Database, based on public-private collaboration.

Figure 1. Paper Map

This is a part of the scale of 1:25,000 topographical maps "Northern and Southern Nagoya" issued by the Geographic Survey Institute.

Figure 2, Digital Map

The digital road map is recorded as a set of numbers and letters. This is an example of a depicted image produced by software that can convert this alphanumeric data into visual form.

2. DATABASE CREATION AND UPDATE

Initially, the DRM Database was created on the basis of the 1:25,000 topographical maps issued by the Geographic Survey Institute (as at April 2009, there are 4,343 maps nationwide). The database has been updated every year based on new topographical maps as well as the information from road administrators nationwide, including the Ministry of Land, Infrastructure and Transport, the prefecture regional governments, the designated city governments, the expressway companies, and the road-related public corporations.

Regarding arterial roads of the prefectural level and higher, we receive construction drawings and other information two years in advance from the respective road administrators concerning the construction of new roads and bypasses, road widening, and other changes. We digitize this information so that the new road map data can be accessed from many systems, including the Vehicle Information and Communication System, as soon as the new roads are opened.

By digitizing the locations and configurations of roads using construction drawings and other

information from road administrators, we are able to accurately depict complicated road configurations, including expressway interchanges and ramps. Any changes in other roads, rivers, lakes, railroads, public facilities, etc. are updated according to the new 1:25,000 topographical maps issued by the Geographic Survey Institute.

Through these endeavors, we ensure that the DRM Database is uniformly accurate and reliable for all over Japan. It is used in many areas by the private sector as well as the public sector including road administrators.

	Total road length	Total link count
Basic roads (5.5m+)	385,000km	1.29million
Supplemental roads (3.0m+)	494,000km	3.49million
All roads	879,000km	4.78million

Table 1. Total road length and total link count in the DRM database

Note: The count of links refers to divided highways; both directions are included in one link. (As of March 31, 2009)

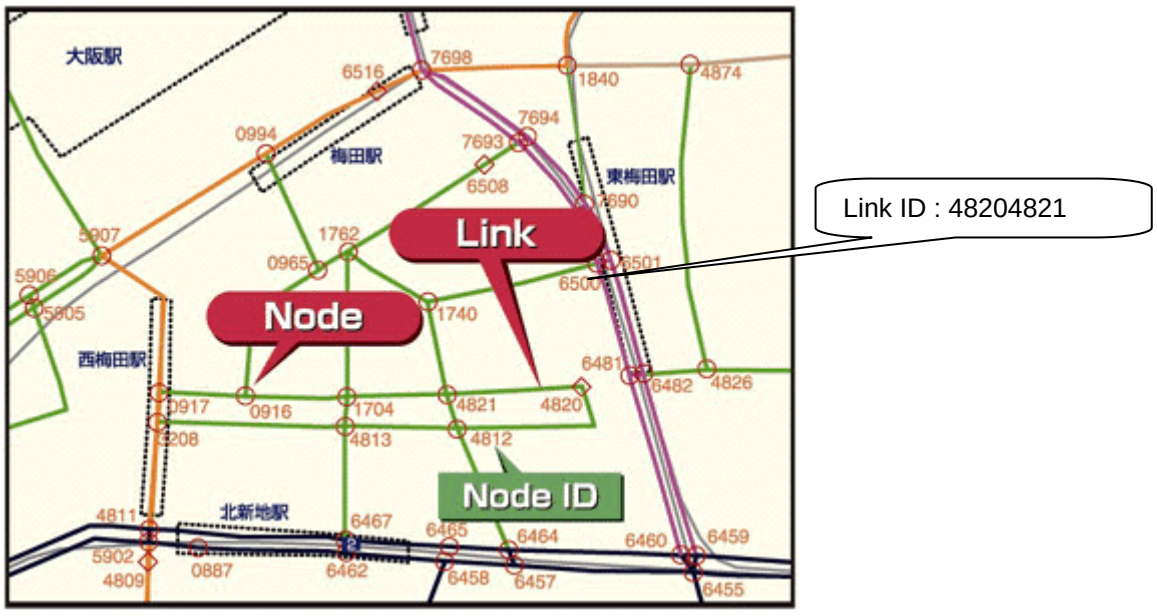
3. DATA MODEL OF ROAD NETWORKS

In the DRM Database, road networks are depicted as combinations of "nodes" and "links" as illustrated below. A unique ID number is assigned to each node and each link.

Node: An intersection or other necessary nodal point of the roadway network.

Link: A road segment between two nodes.

Figure 3, Nodes and Links



Note: A link ID number consists of the ID numbers of the nodes on both ends of the link, starting with the smaller ID number.

4. CHARACTERISTICS OF THE DIGITAL ROAD MAP

The characteristics of the digital road map, especially the DRM Database, are as follows:

The data structure is suitable for depicting networks, and allows computerized searches for the route with the shortest distance, time, etc.

Data on arterial roads of the prefectural level and higher is updated in advance of road openings and other changes. This data is highly precise, based on large-scale construction planning maps provided by road administrators. Other data is updated all at once when new topographic maps are issued.

In addition to the location information, the DRM Database also includes a great deal of other data such as each road's administrator, route number, width, and road structures such as bridges and tunnels.

In addition to establishing and publishing the database standards, DRM also assigns unique node and link IDs. These IDs are shared in the public and private sectors and used when exchanging information related to road traffic, including construction, accidents, and congestion. The DRM Database is an authoritative database serving as a common infrastructure for the exchange of various types of information among public and private entities.

5. DATABASE STANDARDS OF THE DRM

The DRM Database is used as a common infrastructure for a wide range of purposes including road management, VICS, car navigation systems, mapmaking, road traffic information systems, and ITS in general. Therefore, we have developed and published database standards in order to improve the convenience of database utilization and to facilitate the exchange of information.

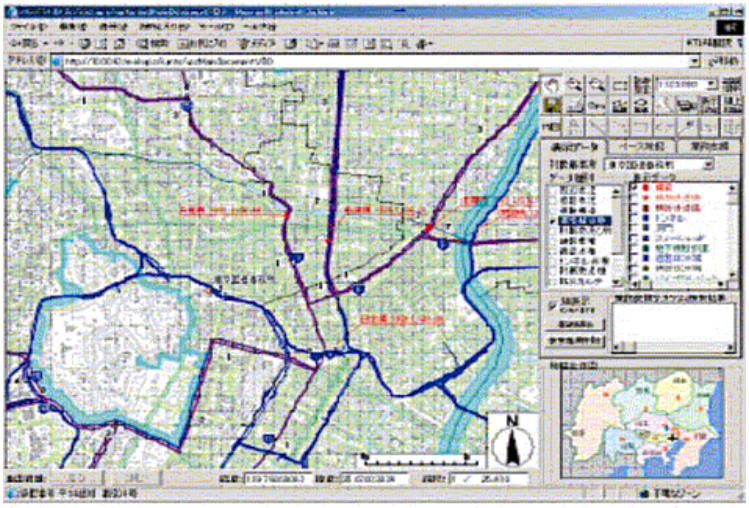
In 1988, the Standardization Committee, composed of interested parties from both the public and private sectors, led the world in developing the first National Digital Road Map Database Standards (the current standards). Since then, the standards have been successively revised as necessary for reasons such as upgrading the database.

6. USES OF DIGITAL ROAD MAP

(1) Road management database system (MICHI)

MICHI (Ministry of Construction Highway Information Data Base System) is a system to organize data on road facilities including bridges, tunnels, and pavement of national roads. It is used for integrated management of the information needed for road maintenance, management, disaster prevention, etc. This system uses the DRM Database for background maps and basic data for calculating the coordinates of road facility locations.

Figure 4.　MICHI SYSTEM



Reference: Road Management Technology Center

(2)　Car navigation systems

These systems accurately match measurements from various sensors and GPS satellites to digital road maps in order to display the current location and indicate the optimal route to the destination. This accurate map information is supported by the DRM Database.

Figure 5. Car navigation system

(3) Vehicle Information and Communication System (VICS)

In VICS, signals from radio beacons, optical beacons, and FM multiplex broadcasting are received by car navigation systems, and information on traffic congestion, regulations, accidents, parking facility vacancies, etc. is displayed in real time on the screen of a car navigation system in the form of text, simple diagrams, and maps. The node data of the DRM Database is stored in the car navigation system, and this is used to display information on congestion, etc. at the road location on the screen.

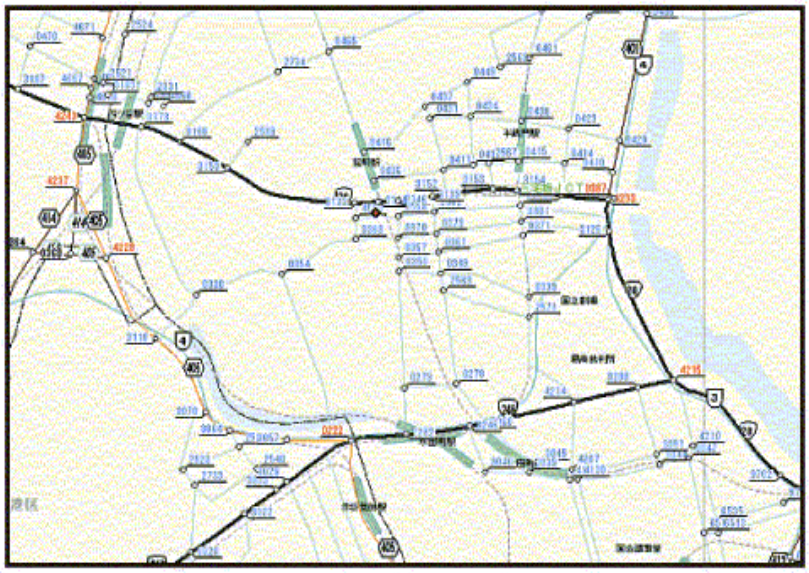
Figure 6. VICS Display

Reference: Homepage of VICS Center

(4) Special vehicle transit permits application system

To operate a special (overweight/oversize) vehicle, a permit must be obtained by filing an application from the office of the national or regional government or other entity which manages the roads of the planned route. The DRM Database is used for the maps of the road information manuals used in route selection. In the case of online applications for special vehicle permits, DRM has also contributed to a new road information system that makes further use of digital road maps to allow easy transit route selection on digital maps.

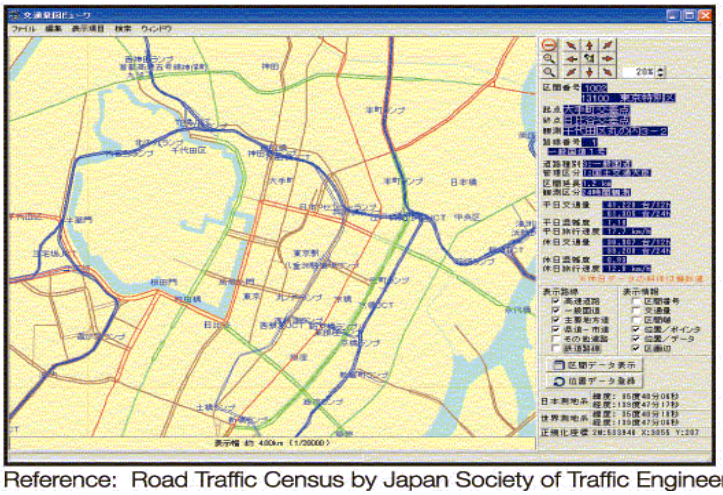
Figure 7. Special vehicle transit permit



(5) Road traffic census analysis

A road traffic census is generally performed once every five years on a national scale. The DRM Database is used for compilation of the survey results, computerized preparation of traffic volume maps, and various analyses of congestion and other factors.

Figure 8. Road traffic census analysis map



Reference: Road Traffic Census by Japan Society of Traffic Engineers (2005)

(6) Sharing of disaster information

Nearly every year, Japan experiences many natural disasters such as earthquakes, typhoons, concentrated torrential rains, and heavy snowfall. Therefore, disaster prevention information is vitally necessary. Digital road maps play an important role as a common information infrastructure in disaster prevention measures by national and regional governments.

Figure 9. Seismic intensity information

(7) Finding alternate routes and selecting emergency transportation routes

Network analysis of the DRM Database provides a timely method for finding alternate routes and selecting and ensuring emergency transportation routes in the case of a large-scale natural disaster.

Examples of other uses related to disaster prevention

>Disaster and road management map information system

>Integrated disaster prevention systems

>Basic data for indices to evaluate the effectiveness of earthquake disaster prevention investment

>Road earthquake information sharing system

>Maps of bridge earthquake resistance strength

Figure 10. Disaster location and alternate routes

7. ITS AND THE DIGITAL ROAD MAP

ITS are new systems which use the latest communication technologies to create an information network of people, roads, and vehicles for the purpose of resolving road traffic problems such as traffic accidents and congestion. Digital road maps play a fundamental role in many areas of ITS, including the advancement of navigation systems and road management.

ITS consists of the following nine areas of development.

>Advancement of navigation systems

>Electronic toll collection systems

>Assistance for safe driving

>Optimization of traffic management

>Improving the efficiency of road management

>Support for public transportation

>Improving the efficiency of commercial vehicles

>Support for pedestrians, etc.

>Support for emergency vehicle operation

8. STUDY OF THE NEXT-GENERATION DIGITAL ROAD MAP

The necessity and importance of the more advanced digital road map for the development of next-generation ITS services has been mentioned in the proposals for the promotion of ITS. Those services are targeting more contribution to increase the road safety as well as to decrease the environmental burden. The National Institute for Land and Infrastructure Management of the Ministry of Land, Infrastructure and Transport has been conducting research on the requirements for data items of the next-generation map in cooperation with private firms and public associations related to ITS including DRM.

Based on this research DRM has started an experimental project to enhance the DRM Database in 2008. The newly collected data items are as follows:

1. Detailed and precise information for complex intersections and expressways.
   - ・Lane information
     Lane center line, lane width, lane border attribute, lane traffic regulation
   - ・Intersection Information
     Stop line, pedestrian crossing, traffic regulation
   - ・Road structure information
     Horizontal alignment, elevation and slope
2. Less precise but widely collected information for most roads
   Horizontal alignment, elevation and slope

Detailed data are expected to be used for development of safer driving assistance systems with help of advanced vehicle positioning technology which is rapidly progressing, while the second type data of curve and elevation are expected to be used to improve existing car navigation systems in the near future.

Figure11. Sample of complex intersections

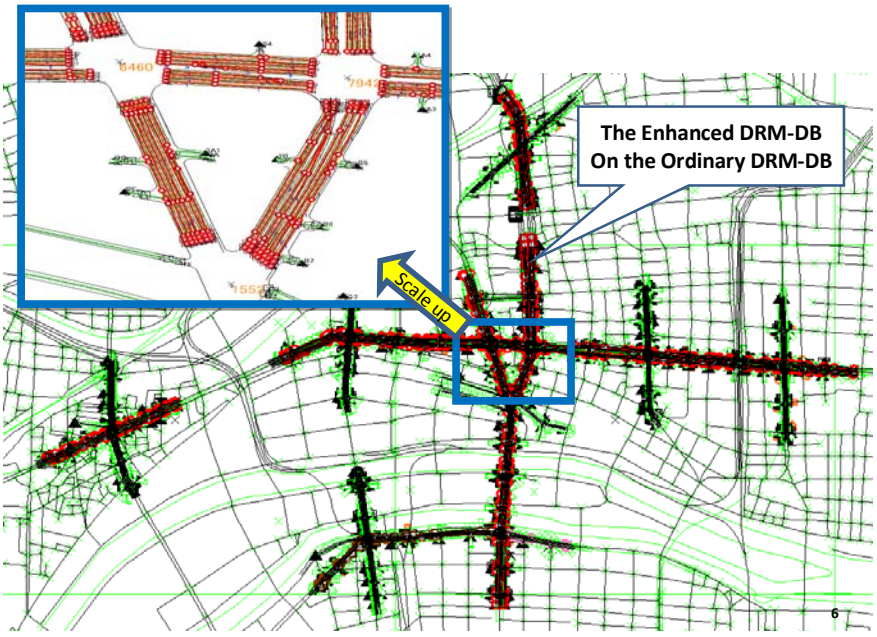


Figure 12. Assistance for safe driving through coordination with maps

9. CONCLUSION

Twenty years has past, since DRM association was established. So many efforts have been made to improve digital road map to apply advanced road management and realize car navigation system.

The DRM Database is used in various different manners nowadays and five million DRM based maps (CD-ROM) were produced in Japan last year.

As referred in the paper, there are new movement in the field of ITS. To realize ITS project, more precise and accurate digital road map is indispensable. One of the problems to provide accurate maps is how to get the information of real roads which are changed. There are so many different kind of roads such as national, prefectural, municipal, agricultural, forestry and so on. It is very hard to get the information from different administrators timely after the road conditions were changed.

We are now proposing a new mechanism to provide road information to the public immediately after new road was constructed or road condition was changed.

Precise and accurate digital road map is important tool for not only road administrator but also public in general to realize Safer, Greener and Smarter Roads.